

**PATENT**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

APPLICANT : **MARUTIAN, Sergey Vasilievich et al.**  
SERIAL NO : 10/500,350  
FILED : February 9, 2005  
TITLE : **METHOD OF APPLYING THE COATINGS FROM ALUMINUM  
ALLOY ON CAST IRON AND STEEL PRODUCTS**

Grp./A.U. : 1792  
Examiner : BAREFORD, Katherine A.  
Conf. No. : 2639  
Docket No. : P06835US00

**RULE 132 DECLARATION OF DR. GERALD S. FRANKEL**

I, Dr. Gerald S. Frankel, state the following:

1. I am a professor of Materials Science and Engineering at The Ohio State University, where I have been employed since 1995. I am also the Director of the Fontana Corrosion Center at The Ohio State University, which conducts research in the field of corrosion. I have received many honors, supervised substantial research projects, have published over 130 peer-reviewed articles, have authored 14 book chapters, have written over 80 proceedings papers and unreviewed reports, and made at least 130 scholarly presentations. I have been involved in the leadership of The Electrochemical Society Corrosion Division and in the Research Committee of the National Association of Corrosion Engineers. I have served on the Board of Editors for the Corrosion Journal for more than 15 years. I have organized various symposiums on numerous corrosion topics. I have served as an expert consultant for numerous entities for nearly 15 years. My Curriculum Vitae is attached.

2. I have reviewed the Marutian published Patent Application No. 2005/0142294, the Amendment dated November 16, 2009, the Office Action dated February 23, 2010, the Rallis Patent No. 4,655,852 and the English Abstract of the Japanese Patent 50005213A.

3. The Marutian application is directed towards a method of applying an aluminum alloy coating to cast iron and steel products at a relatively low melt temperature with a goal of good adhesion and ductility. See paragraphs 4, 5 and 7 of the published Marutian Patent Application.

4. The Rallis Patent is directed towards a method of aluminizing steel so as to form an intermetallic layer as an integral part of the steel article while maintaining the high strength of the steel. See the Rallis Abstract, col. 2, lines 34-51; and Example I and Example II.

5. The Japanese Patent is directed towards an automotive radiator having improved corrosion resistance, provided by an aluminum alloy.

6. Metallurgically, strength and ductility are inversely related. Thus, the Rallis goal of maintaining high strength in an aluminized steel product also results in a brittle product having low ductility. On the other hand, the aluminum alloy coating of Marutian provides increased ductility, but decreased coating strength, as compared to the aluminizing process of Rallis.

7. In my opinion, it would not be obvious to modify the Rallis aluminizing process by substituting an aluminum alloy, such as disclosed in the Japanese patent, for a bath time of 40-120 seconds, at a temperature between 660-680° C, because such a modification would not achieve the metal interdiffusion results of Rallis. In particular, the Rallis process requires more than five minutes (col. 2, lines 34-51), such as 30 minutes at 1300° F (col. 3, lines 60-62), and up to two hours (Example II) to provide for the desired interdiffusion of the

aluminum and steel. Rallis' optimal temperature range is 1000° F - 1341° F (538° C-727° C), as described at col. 5, lines 5-20. The higher the bath temperature, the lower the bath time (Rallis, col. 4, lines 47-63). For example, 2000° F (1093° C), the time is only about 2 minutes, but at 800° F (427° C), the time is several hours. Rallis, col. 4, lines 60-63. The Marutian temperature 660°-680° C (1220° - 1256° F) at 40-120 seconds will not produce interdiffused steel and aluminum, as desired by Rallis.

The undersigned further declares that all statements made herein of his own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application of any patent issuing thereon.

Date August 17, 2010



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DR. GERALD S. FRANKEL

### **Dr. Gerald S. Frankel: Curriculum Vitae, 2010**

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#### **Employment/Education**

- 2007- DNV Chair in Corrosion, The Ohio State University
- 1995- Director, Fontana Corrosion Center, OSU
- 1995- Professor (1999-) and Associate Professor of Materials Science and Eng., OSU
- 2009- Adjunct Professor, Pohang Institute of Science and Technology, Graduate Institute of Ferrous Technology, Pohang, Korea
- 2008 Invited Professor, University Pierre and Marie Curie, Paris
- 2004-05 Visiting Scientist, Max Planck Inst. For Iron Research, Dusseldorf, Germany
- 1986-95 Research Staff Member, IBM T.J. Watson Research Center, Yorktown Heights, NY
- 1985-86 Post-Doctoral Associate, Swiss Federal Technical Institute, Zurich, Switzerland
- 1985 Sc.D., Materials Science and Engineering, MIT, Cambridge, MA
- 1980-84 Graduate Research Assistant, MIT
- 1978-80 Staff Scientist, Arthur D. Little Inc., Cambridge, MA
- 1978 Sc.B., Materials Science and Engineering, Brown University, Providence, RI

#### **Honors**

- U.R. Evans Award of the UK Institute of Corrosion, 2011.
- H.H. Uhlig Award from the Corrosion Division of The Electrochemical Society, 2010.
- Ohio State University Distinguished Scholar Award, 2010.
- Fellow of the following societies: NACE International, 2004; The Electrochemical Society, 2006; ASM International, 2006.
- Alexander von Humboldt Foundation Research Award for Senior US Scientists, 2003.
- Lee Hsun Lecture Award of the Institute for Metal Research, Shenyang, China, 2010.
- H.H. Uhlig Educator award of NACE International, 2000.
- T.P. Hoar Prize from the UK Institute of Corrosion for best paper published in *Corrosion Science* in 2007 (Paper 95 below); W.H. Hobart Award from the American Welding Society, 2003 (Paper 71 below).
- Recipient of several OSU College of Engineering Awards: Harrison Faculty Award, 2000;

Lumley Research Award, 1999, 2003, 2010; Lumley Interdisciplinary Research Award, 2006; Research Accomplishment Award, 1997.

- Work on Cr-free consumable for welding stainless steels chosen as 2007 Project of the Year by the Strategic Environmental Research and Development Program, SERDP.
- Chairman of 2000 Gordon Conference on Aqueous Corrosion, Invited lecturer for 1994, 1996, 1998, and 2006 Gordon Conferences on Aqueous Corrosion.
- Recipient of IBM Outstanding Technical Achievement Award, 1992.
- Work on corrosion sensing paint was highlighted in many magazines including *Business Week*, *Aviation Weekly*, *R&D News*, *AFRL Research Highlights*
- 10 plenary or keynote talks:
  - Plenary Lecture at ISE Annual meeting, Nice, France, 2010.
  - Introductory Keynote Address at Australasian Corrosion Association conference, Coff's Harbour, Australia, 2009.
  - Plenary lecture at Corrosion2009, Atlanta, 2009.
  - Plenary lecture at EUROCORR 2008, Edinburgh, 2008.
  - Plenary lecture at ASTM Symposium on Advances in Electrochemical Techniques for Corrosion Monitoring and Measurement, Norfolk, 2007.
  - Plenary Lecture at 16<sup>th</sup> International Corrosion Congress, Beijing, 2005.
  - Keynote Address, Passivity-9, Paris, 2005.
  - Introductory Plenary Lecture at International Symposium "Corrosion Science in the 21st Century", UMIST, Manchester, England, 2003.
  - Plenary address at 12<sup>th</sup> Asia-Pacific Corrosion Control Conference, Seoul, Korea, 2001.
  - Keynote address at 8th International Symposium on Passivity of Metals and Semiconductors, Jasper, Canada, 1999.
- H.H. Uhlig Student Award presented by NACE New England Chapter, 1984, International Nickel Co. Graduate Fellow, 1980-84, Elected to Tau Beta Pi and Sigma Xi.
- More than 130 technical presentations, more than 200 publications.

### **Supervision of Research**

Currently advising 13 graduate students; 14 PhD and 8 MS degrees granted; 19 post-docs and visiting scholars supervised:

#### Ph.D. degrees:

- Jian Zhang, "Development and Characterization of Corrosion Sensing Coating Systems," 1999, currently with Austra, Palo Alto, CA.
- Donghui Lu, "The Influence of Inhibitor Ions on Localized Corrosion of Al and Al Alloys," 2000, currently with Intel, San Jose.
- Thodla Ramgopal, "Role of Grain Boundary Precipitates and Solute Depleted Zone in the Intergranular Corrosion of Aluminum Alloy AA7150," 2001, currently with DNV, Dublin, OH. *ECS Morris Cohen award winner*.
- Weilong Zhang, "Localized Corrosion Kinetics in High Strength AA2024 Alloys," 2001, currently with United Technologies Research Center, Hartford.

- \*Qingjiang Meng, "Effect of Cu Content on Corrosion Behavior and Chromate Conversion Coating Protection of 7xxx Series Al Alloys," 2003, currently with Honeywell Corrosion Solutions, Houston. *ECS Morris Cohen award winner.*
- \*Xiaodong Liu, "Effects of Stress on Intergranular Corrosion and Intergranular Stress Corrosion Cracking in AA2024-T3," 10/2005, currently with Caterpillar, Peoria, IL.
- Tsai-Shang Huang, "Localized Corrosion Growth Kinetics in AA7xxx Alloys," 10/2005, currently with China Steel Co., Taiwan.
- Yeong Ho Kim, "Cr-Free Consumable for Welding Stainless Steel," 11/2005, currently with Pohang Steel Corp, Pohang, Korea.
- \*Xinyan Zhao, "Exfoliation Corrosion Kinetics in AA7xxx Alloys," 1/2006, currently with Intel, Phoenix, AZ.
- \*Jiho Kang, "Corrosion Studies of Thin Film Samples," 1/2006, currently with Intel, Portland, OR.
- \*Mariano Iannuzzi, "Mechanisms of Corrosion Inhibition of AA2024-T3 by Vanadates," 8/2006, currently with DNV, Oslo, Norway. *ECS Morris Cohen award winner.*
- Zhijun Zhao, "Role of Surface Active Layers on Localized Breakdown of Aluminum Alloy 7075," 10/2006, currently with FormFactor, Livermore, CA.
- \*Dong Liang, "Environmental and Alloying Effects on Corrosion of Metals and Alloys," 6/2009, currently with DNV, Dublin, OH.
- Bastian Maier, "Electrochemical Studies under Thin Electrolyte Layers using a Kelvin Probe," 6/2010.

\* denotes poster award winner

#### M.S. degrees, thesis option:

- Mohammad Al-Anezi, "The Susceptibility of Conventional ASTM A516-70 to HIC and SOHIC in H<sub>2</sub>S-Containing DGA Environments," 1998, currently with Saudi Aramco.
- Myna Bisineer, "EIS Study of Polymer Thin Films on Thin Film Metal Substrates," 3/99, took a job with i2 Technologies, Cambridge, MA.
- \*Gregory Omweg, "Sulfide Stress Cracking Resistance of Welded High-Strength Low-Alloy Steels," 2001, currently with FormFactor, Singapore.
- Younghoon Baek, "Electrochemical Quartz Crystal Microbalance Study of Corrosion of Phases in AA2024-T3," 2002, enrolled in business school.
- Ajit Mishra, 2008, "Crevice Corrosion Repassivation of Alloy 22 in Aggressive Environments," enrolled in PhD program at Univ. of Western Ontario.
- Emerson Nunez-Moran, 2010, "Evaluation of the Localized Corrosion Resistance of 21Cr Stainless Steels," currently with Baker Hughes, Houston.
- Sean Xi Chen, 2010, "Corrosion Resistance Assessment of Pretreated Magnesium Alloys," currently with General Motors, Warren, MI.

\* denotes poster award winner

#### M.S. degrees, non-thesis option:

- Junye Zhu, 1998.
- Uthai Tabattanon, 2000, currently with Unocal, Thailand.

#### Foreign Diploma/MS/PhD Theses directed and visiting PhD Students advised:

- Serge Hauert, 1997, from EPFL, Switzerland.
- Francois Buellmann, 2002, from EPFL, Switzerland.
- Mariano Kappes, 2006, from Argentina.
- Francois Marie, 2007, from France.
- Severine Cambier, 2008, from France.
- Yoshihiko Kyo, 2008, from Japan.
- Lina Toro, 2009, from Spain.
- Masoud Atapour, 2009, from Iran.

Post-docs/visiting scientists supervised:

- Zaizhu Xia, 1995-1996, currently with Lucas Aerospace, Cleveland, OH
- Akshey Sehgal, 1996-97, currently with National Semiconductor, Portland, ME.
- Eiji Akiyama, 1997-99, currently with NIMS, Tsukuba, Japan.
- Patrick Schmutz, 1997-2000, currently with EMPA, Zurich, Switzerland.
- Valerie Guillaumin, 1999-2000, currently with Airbus, Toulouse, France.
- Delphine Herbert-Guillou, 2000-01, currently with Ugine SA, Isbergues, France.
- Liliana Lanzani, 2003, currently with Comision Nacional de Energia Atomica, Argentina.
- Patrick Leblanc, 2000-03, currently with Avestor, Boucherville, Canada.
- Zhihua Sun, 2003-04, currently with Beijing Inst. of Aeronautical Materials
- Eun Young Na, 2004, currently with Mokpo Maritime University, Korea.
- Eiji Tada, 2004-2005, currently with Akita University, Japan.
- Yumei Zhai, 2005-2008, currently with DNV, Dublin, OH.
- Shoichiro Taira, 2006-2008, currently with JFE Steel Corp, Japan.
- Aixiang Zeng, 2007-2008, currently with Changsha University of Science and Technology, China.
- Hideki Katayama, 2007-2008, currently with NIMS, Tsukuba, Japan.
- Saikat Adhikari, 2008-
- Jin-Feng Li, 2009-
- Ralf Posner, 2009-
- Koichi Ishikawa, 2010-

**Personal**

Date of birth: January 14, 1957, Pittsburgh, PA; married, two children.

**Current Research Interests**

The following subjects are being actively researched in 2010: role of oxidizing species and UV light in atmospheric corrosion; surface treatments for steel and Al; adhesion of organic coatings on metals and the degradation of that adhesion; studies of non-chromate inhibitors; corrosion and stress corrosion of steel in ethanol; corrosion of corrosion resistant alloys under thin layers of electrolyte; catalysts for electrochemical reduction of CO<sub>2</sub>; electropolishing of welded Nb; corrosion of welded Ti alloys; corrosion of new ferritic stainless steels.

**Peer-reviewed Publications**

134. Desheng Sun, William A. Brantley, Gerald S. Frankel, and Reza Heshmati, "Potentiodynamic polarization study of the corrosion behavior of palladium-silver dental alloys," submitted to *J. Prosthetic Dent.*, 8/10.
133. Bastian Maier and G.S. Frankel, "Pitting Corrosion of Silica Coated SS304 Under Thin Electrolyte Layers," submitted to *Corrosion*, 6/10.
132. Jeffrey W. Sowards, Dong Liang, Boian T. Alexandrov, Gerald S. Frankel, John C. Lippold, "Influence of dilution and microsegregation on solidification behavior of dissimilar welds between a Ni-Cu welding consumable and austenitic stainless steel," submitted to *Weld. J.*, 5/10.
131. Kemal Nisancioglu, Anawati, Brit Graver, Heidi Nordmark, Zhijun Zhao, G.S. Frankel, and John Walmsley, "Multilayer Corrosion of Aluminum Activated by Lead," submitted to *J. Electrochem. Soc.* 4/10.
130. Bastian Maier and G.S. Frankel, "Pitting Corrosion of Bare Stainless Steel 304 under Chloride Solution Droplets," accepted for publication in *J. Electrochem. Soc.*, 7/10.
129. J.W. Sowards, D. Liang, B.T. Alexandrov, G.S. Frankel, J.C. Lippold, "Solidification behavior and weldability of dissimilar welds between a Cr-free, Ni-Cu welding consumable and Type 304L austenitic stainless steel," submitted to *Met. Trans. A.* 4/10.
128. Saikat Adhikari, K.A. Unocic, Y. Zhai, G.S. Frankel, John Zimmerman, and W. Fristad, "Hexafluorozirconic Acid Based Surface Pretreatments: Characterization and Performance Assessment," accepted for publication in *Electrochim. Acta*, 7/10.  
doi:10.1016/j.electacta.2010.07.037
127. M. Atapour, A. Pilchak, G.S. Frankel, J.C. Williams, M.H. Fathi, and M. Shamanian, "Corrosion Behavior of Ti-6Al-4V with Different Thermomechanical Treatments and Microstructures," accepted for publication in *Corrosion*, 3/10.
126. M. Atapour, A. Pilchak, G.S. Frankel, and J.C. Williams "Corrosion Behavior of Friction Stir and Gas Tungsten Arc Welded Ti-6Al-4V," *Met. Mat. Trans. A*, **41**, (2010) 2318.
125. M. Kappes, G.S. Frankel and N. Sridhar, "Study of Adhesion and Adhesion Degradation of a Pressure Sensitive Tape on Carbon Steel," *Prog. Org. Coat.*, **69** (2010), 57-62.
124. M. Atapour, A. Pilchak, G.S. Frankel, and J.C. Williams "Corrosion Behavior of Investment Cast and Friction Stir Processed Ti-6Al-4V," *Corros. Sci.*, **52** (2010) 3062–3069.
123. Gerald Sigua, Saikat Adhikari, G.S. Frankel and Melvin A. Pascall, "The Use of Atomic Force Microscopy to Measure the Efficacies of Various Chemical Sanitizers in Removing Organic Matter from Glass Surfaces" *J. Food Eng.*, **100** (2010) 139-144.



122. Z. Y. Chen, D. Liang, G. Ma, G. S. Frankel, H. Allen, and R. G. Kelly, "Influence of UV Irradiation and Ozone on the Atmospheric Corrosion of Bare Silver," *Corr. Eng. Sci. Tech.*, **45**, (2010) 169-180.
121. D. Liang, J.W. Sowards, G.S. Frankel, B.T. Alexandrov and J.C. Lippold, "Corrosion Resistance of Welds in 304L Stainless Steel Made with a Nickel-Copper-Ruthenium Welding Consumable," *Corros. Sci.* **52** (2010) 2439-2451.
120. D. Liang, H. C. Allen, G. S. Frankel, Z. Y. Chen, and R. G. Kelly, "Effects of Sodium Chloride Particles, Ozone, UV, and Relative Humidity on Atmospheric Corrosion of Silver," *J. Electrochem. Soc.*, **157**, (2010) C146-156.
119. D. Liang, J.W. Sowards, G.S. Frankel, B.T. Alexandrov and J.C. Lippold, "A Corrosion Study of Nickel-Copper and Nickel-Copper-Palladium Welding Filler Metals," *Mat. Corr.* (2010), DOI: 10.1002/maco.200905583.
118. S. Taira and G.S. Frankel, "Localized Corrosion of Ni Based Alloys Under Thin Electrolyte Layers," *Corrosion & Materials (Australia)*, **35** (1), (2010) 39-47.
117. G.S. Frankel, "Assessing Corrosion Education," *Mat. Perf.*, **48** (2009) 28-34.
116. Aldo Handojo, Yumei Zhai, Gerald Frankel and Melvin A. Pascall, "Measurement of adhesion strengths between various milk products on glass surfaces using contact angle measurement and atomic force microscopy," *J. Food Eng.*, **92** (2009) 305-311.
115. G.S. Frankel and M. Stratmann, "Future Perspectives of Corrosion Science," *Corros. Eng. Sci. Tech.*, **44**, (2009) 328-331.
114. A.K. Mishra and G.S. Frankel, "Crevice Corrosion Repassivation of Alloy 22 in Aggressive Environments," *Corrosion*, **64**, (2008) 836-844.
113. G. S. Frankel and N. Sridhar, "Understanding Localized Corrosion," *Materials Today*, **11** (2008) 38-44.
112. M. Kappes, L. Kovarik, M.J. Mills, G.S. Frankel, and M.K. Miller, "The Usefulness of Ultra-High Resolution Microstructural Studies for Understanding Localized Corrosion Behavior of Al Alloys," *J. Electrochem. Soc.*, **155**, (2008) C437-C443.
111. G. S. Frankel, "Electrochemical Techniques in Corrosion; Status, Limitations and Needs," *J. ASTM Int.*, **5**, Issue 2 (2008) online ISSN: 1546-962X, DOI: 10.1520/JAI101241, <http://www.astm.org/JOURNALS/JAI/TOC/JAI522008.htm>.
110. Tsai-Shang Huang, Shang Zhao, G. S. Frankel and D. A. Wolfe, "A Statistical Model for Localized Corrosion in 7xxx Aluminum Alloys," *Corrosion*, **65**, (2007) 819-827.

109. E. Tada and G. S. Frankel, "Effect of Particulate Silica Coatings on Localized Corrosion Behavior of AISI 304SS under Atmospheric Corrosion Conditions," *J. Electrochem. Soc.*, **154**, (2007) C318-C325.
108. E. Tada and G. S. Frankel, "Electrochemical Behavior of AISI 304SS with Silica Coating in 0.1 M NaCl," *J. Electrochem. Soc.*, **154**, (2007) C312-C317.
107. Tsai-Shang Huang and G. S. Frankel, "Effects of Temper and Potential on Localized Corrosion Kinetics of AA7075," *Corrosion*, **65**, (2007) 731-743.
106. Zhijun Zhao and G. S. Frankel, "Surface Layer Dissolution Kinetics of AA7075 in Various Tempers," *Corrosion*, **63**, (2007) 613-624.
105. M. Iannuzzi and G. S. Frankel, "Inhibition of AA2024-T3 Corrosion by Vanadates: An AFM Scratching Investigation" *Corrosion*, **63**, (2007) 672-688.
104. Zhijun Zhao and G. S. Frankel, "The Effect of Temper on the First Breakdown in AA7075," *Corros. Sci.*, **49**, (2007) 3089-3111.
103. Zhijun Zhao and G. S. Frankel, "On the First Breakdown in AA7075-T6," *Corros. Sci.*, **49**, (2007) 3064-3088.
102. M. Iannuzzi and G. S. Frankel, "Mechanisms of Corrosion Inhibition of AA2024-T3 by Vanadates" *Corros. Sci.*, **49**, (2007) 2371-2391.
101. Shang Zhao, Douglas A. Wolfe, Tsai-Shang Huang, and Gerald S. Frankel, "Generalized Model for IGC Growth in Aluminum Alloys," *J. Statistical Planning and Inference*, **137**, (2007) 2405-2412.
100. G. S. Frankel, M. Stratmann, M. Rohwerder, A. Michalik, B. Maier, J. Dora, and M. Wicinski, "Potential control under thin aqueous layers using a Kelvin Probe," *Corros. Sci.*, **49**, (2007) 2021-2036.
99. M. Iannuzzi, J. Kovac, and G. S. Frankel, "A Study of the Mechanisms of Corrosion Inhibition of AA2024-T3 by Vanadates Using the Split Cell Technique," *Electrochim Acta*, **52**, (2007) 4032-4042.
98. Yeong Ho Kim and G. S. Frankel, "Effect of Noble Element Alloying on Passivity and Passivity Breakdown of Ni," *J. Electrochem. Soc.*, **154** (2007) C36-C42.
97. Xinyan Zhao and G. S. Frankel, "Quantitative Study of Exfoliation Corrosion: Exfoliation of Slices in Humidity Technique," *Corros. Sci.*, **49** (2007) 920-938.
96. Tsai-Shang Huang and G. S. Frankel, "Sharp Intergranular Corrosion Fissures in AA7178," *Corros. Sci.*, **49** (2007) 858-876.

95. Xiaodong Liu, G. S. Frankel, B. Zoofan and S.I. Rokhlin, "In Situ Observation of Intergranular Stress Corrosion Cracking in AA2024-T3 under Constant Load Conditions," *Corros. Sci.* **49** (2007) 139-148.
94. Xinyan Zhao and G. S. Frankel, "Effects of RH, Temper and Stress on Exfoliation Corrosion Kinetics of AA7178," *Corrosion*, **62** (2006) 256-266.
93. M. Iannuzzi, T. Young and G. S. Frankel, "Aluminum Alloy Corrosion Inhibition by Vanadates," *J. Electrochem. Soc.*, **153** (2006) B533-B541.
92. Xiaodong Liu and G. S. Frankel, "Effects of Compressive Stress on Localized Corrosion in AA2024-T3," *Corros. Sci.*, **48** (2006) 3309-3329.
91. Tsai-Shang Huang and G. S. Frankel, "The Influence of the Grain Structure on Anisotropic Localized Corrosion Kinetics of AA7xxx-T6 Alloys," *Corros. Eng. Sci. Tech.*, **41** (2006) 192-199.
90. B. Zoofan, J.-Y. Kim, S. I. Rokhlin, and G. S. Frankel, "Phase-contrast X-ray imaging for nondestructive evaluation of materials," *J. Appl. Phys.*, **100** (2006) 014502-1 – 014502-7.
89. Yeong Ho Kim, G. S. Frankel, and J. C. Lippold, "Development of a Chromium-free Consumable for Austenitic Stainless Steels: Effect of Dilution and the Behavior of Bead-on-Plate Welds," *ISIJ International*, **46**, (2006) 698-704.
88. Xiaodong Liu, G. S. Frankel, B. Zoofan and S. I. Rokhlin, "In Situ X- ray Radiographic Study of Stress Corrosion Cracking in AA2024-T3," *Corrosion*, **62**, 217-230 (2006).
87. Yeong Ho Kim, G. S. Frankel and J. C. Lippold "Cr-free Consumables for Welding Stainless Steel. Part 2: Optimization of Alloy Composition Based on Corrosion Behavior," *Corrosion*, **62**, 109-120 (2006).
86. Xiaodong Liu, G. S. Frankel, B. Zoofan and S.I. Rokhlin, "The Transition from Intergranular Corrosion to Intergranular Stress Corrosion Cracking in AA2024-T3, *J. Electrochem. Soc.*, **153**, B42-B51 (2006).
85. Yeong Ho Kim, G. S. Frankel, J. C. Lippold and G. Guaytina, "Cr-free Consumables for Welding Stainless Steel. Part 1: Monel," *Corrosion*, **62**, 44-53 (2006).
84. Jiho Kang and G. S. Frankel, "Potentiostatic Pulse Testing for Assessment of Early Coating Failure," *Z. Phys. Chemie*, **219**, 1519-1538 (2005).
83. B. Zoofan, J.-Y Kim, S. I. Rokhlin and G. S. Frankel, "Application of Phase-Contrast Microradiography in NDT," *Mat. Eval.*, **63**, 1122-1127 (2005).
82. Qingjiang Meng and G. S. Frankel, "Effect of Cu Content on Chromate Conversion Coating Protection of 7xxx-T6 Aluminum Alloys," *Corrosion*, **60**, 897-904 (2004).

81. Qingjiang Meng and G. S. Frankel, "Effect of Cu Content on Corrosion Behavior of 7xxx Series Aluminum Alloys," *J. Electrochem. Soc.*, **151**, B271-283 (2004).
80. Qingjiang Meng and G. S. Frankel, "Characterization of Chromate Conversion Coating on AA7075-T6 Aluminum Alloy," *Surf. Int. Anal.*, **36**, 30-42 (2004).
79. Patrick P. Leblanc and G. S. Frankel, "Investigation of Filiform Corrosion of Epoxy-Coated 1045 Carbon Steel by Scanning Kelvin Probe Force Microscopy," *J. Electrochem. Soc.*, **151** B105-113 (2004).
78. Q. Meng, G. S. Frankel, H. O. Colijn and S. H. Goss, "High Resolution Characterization of the Region around MnS Inclusions in Stainless Steel Alloys," *Corrosion*, **60**, 346-355 (2004).
77. Shiling Ruan, D. A. Wolfe, and G. S. Frankel, "Statistical Modeling and Computer Simulation of Intergranular Corrosion Growth in AA2024-T3 Aluminum Alloy," *J. Stat. Plan. Inference*, **126**, 553-568 (2004).
76. Xiaodong Liu, G. S. Frankel, B. Zoofan and S. I. Rokhlin, "Effect of Applied Tensile Stress on Intergranular Corrosion of AA2024-T3," *Corros. Sci.*, **46**, 405-425 (2004).
75. S. Ruan, D. Wolfe, Weilong Zhang, and G. S. Frankel, "Statistical Modeling of Minimum Intergranular Corrosion Path Length in High Strength Aluminum Alloy," *Technometrics*, **46**, 69-75 (2004).
74. X. Zhao, G. S. Frankel, B. Zoofan, and S. I. Rokhlin, "In situ X-Ray Radiographic Study of Intergranular Corrosion in Al Alloys," *Corrosion*, **59**, 1012-1018 (2003).
73. G. M. Omweg, G. S. Frankel, W. A. Bruce, and G. Koch, "The Performance of Welded High-Strength Low-Alloy Steels in Sour Environments," *Corrosion*, **59**, 640-53 (2003).
72. Q. Meng, G. S. Frankel, H. O. Colijn and S. H. Goss, "Characterization of the Region around MnS Inclusions in Stainless Steel Alloys," *Nature*, **424**, 389-90 (2003).
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#### **Patents**

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#### **Scholarly Presentations (only those given by GSF)**

139. B. Maier, S. Taira, and G.S. Frankel, "Localized Corrosion Under Droplets and Thin Electrolyte Layers," Australasian Corrosion Conference, Coff's Harbour, Australia, 11/16/09 **introductory keynote address**.
138. B. Rincon Troconis, Y. Guo, K. Unocic, S. Adhikari and G. S. Frankel, "Cr-Free and Phosphate-Free Surface Treatments for Steel and Al Alloys," ECS Fall Meeting, Vienna, 10/5/09.
137. D. Liang, G.S. Frankel, C. Lemon, and H.C. Allen, "Effects of Cl<sup>-</sup>, UV, O<sub>3</sub>, and RH Atmospheric Corrosion of Ag," Corrosion2009, Atlanta, 3/24/09.
136. G.S. Frankel, "The Future of Corrosion Education and the Effects on NACE International," Corrosion2009, Atlanta, 3/23/09 **plenary address**.
135. Y. Zhai, G.S. Frankel, J. Zimmerman, W. Fristad, A. Seyeux, A. Galtayries, P. Marcus, "Hexafluorozirconic Acid Surface Treatments for Steel Substrates," Taiwan 2008 International Steel Technologies Symposium, Kaohsiung, Taiwan, 11/4/08, **invited talk**.
134. D. Liang, G.S. Frankel, Z. Chen, R.G. Kelly, G. Ma, H. Allen, Y. Wu, and B. Wyslouzil, "Atmospheric Corrosion of Ag; Effects of Cl<sup>-</sup>, UV, O<sub>3</sub>, and RH," ECS Fall Meeting, Honolulu, 10/15/08.

133. Y. Zhai, Y. Guo, G.S. Frankel, J. Zimmerman and W. Fristad, "Chromate-free Surface Treatments for Al Alloy and Steel Substrates," 17th International Corrosion Congress, Las Vegas, 10/08/08.
132. Y. Zhai, Y. Guo and G.S. Frankel, "Nanoscale Cr-free Conversion Coatings for Al Alloy and Steel Substrates," ENMT 2008, Ein Gedi, Israel, 9/18/08, **invited lecture**.
131. D. Liang and G.S. Frankel, "Role of Ozone and UV Light in Atmospheric Corrosion of Ag," EUROCORR 2008, Edinburgh, Scotland, 9/11/08, **plenary lecture**.
130. G.S. Frankel, "Activities in the Fontana Corrosion Center," Laboratory on Physical Chemistry of Surfaces, ENSCP, Paris, 7/7/2008.
129. G.S. Frankel, "Activities in the Fontana Corrosion Center," Laboratory on Interfaces and Electrochemical Systems, University of Pierre and Marie Curie, Paris 6, 7/1/2008.
128. Dong Liang, G.S. Frankel, G. Ma, H. Allen, Y. Wu, B. Wyslouzil, Z. Chen, B. Keene, and J. Fuentes, "Role of Reactive Chloride Species in Atmospheric Corrosion of Ag," NACE Corrosion2008, Research in Progress, New Orleans, 3/18/08.
127. G.S. Frankel, M. Kappes, L. Kovarik, M.J. Mills, and M.K. Miller, "The Usefulness of Ultra-High Resolution Microstructural Studies for Understanding Localized Corrosion Behavior of Al Alloys," Chalmers Univ., Gothenburg, Sweden 01/22/08.
126. X. Liu and G. S. Frankel, "Effects of Stress on the Localized Corrosion Behavior of Al Alloys" ECS Meeting, Washington, DC 10/9/07.
125. G.S. Frankel, M. Kappes, L. Kovarik, and M.J. Mills, "The Usefulness of Ultra-High Resolution Microstructural Studies for Understanding Localized Corrosion Behavior of Al Alloys," ECS Meeting, Washington, DC 10/11/07.
124. "Crevice Repassivation Potential for Alloy 22 in Different Environments," A.K. Mishra and G.S. Frankel, AS&T Conference, Detroit, 9/19/07.
123. "The Kelvin Probe: A Powerful Tool for Electrochemistry," G.S. Frankel, Sandia National Labs, Chemistry and Physics Colloquium, 7/11/07, **invited talk**.
122. "Effects of Surface Deformation from Polishing on Corrosion of Al Alloys," Z. Zhao, G. S. Frankel, Workshop on Cold Work in Iron- and Nickel-Base Alloys Exposed to High Temperature Water Environments, AECL and EPRI meeting, Toronto, 6/5/07.
121. "Electrochemical Techniques in Corrosion; Status, Limitations and Needs," G. S. Frankel, ASTM Symposium on Advances in Electrochemical Techniques for Corrosion Monitoring and Measurement, Norfolk, 5/22/07, **plenary lecture**.

120. "Corrosion Education: Materials Science," G.S. Frankel, Materials Forum 2007, Corrosion Education for the 21<sup>st</sup> Century, National Academies, National Materials Advisory Board meeting, Washington, 3/30/07, **invited talk**.
119. "Development of Ni-Cu Consumables for Welding of Austenitic Stainless Steels ," Dong Liang, G.S. Frankel, J. Sowards, B. Alexandrov, J.C. Lippold, NACE Corrosion2007, Research in Progress, Nashville, 3/12/07.
118. "Effect of Nano-Scale Segregation on Localized Corrosion of Al Alloys", G. S. Frankel and M. Kappes, Workshop on Future Perspectives in Corrosion Research, Ringberg Castle, Tegernsee, Germany, 12/15/06, **invited talk**.
117. "Inhibition of AA2024-T3 Corrosion by Vanadates," M. Iannuzzi and G. S. Frankel, ECS Meeting, Cancun, 11/1/06, **invited talk**.
116. "Atomic Force Microscopy, A Tool for Surface Characterization," G. S. Frankel, MS&T'06 conference, Cincinnati, 10/16/06, **invited talk**.
115. "Al Alloy Corrosion and Inhibition," G. S. Frankel, Univ. of Ljubljana, Slovenia, 9/6/06, **invited talk**.
114. "On the First Breakdown Potential in AA7xxx Alloys," Z. Zhao and G.S. Frankel, Gordon Research Conference on Aqueous Corrosion, New London, NH, 7/17/06, **invited talk**.
113. "Inhibition of Al Alloy Corrosion by Vanadates," M. Iannuzzi and G. S. Frankel, Fourth Aluminum Surface Science and Technology Symposium, Beaune, France, 5/16/06.
112. "Effects of Compressive Stress on Intergranular Corrosion in AA2024-T3," X. Liu and G. S. Frankel, Fourth Aluminum Surface Science and Technology Symposium, Beaune, France, 5/18/06.
111. "Localized Corrosion," G. S. Frankel, Caterpillar Corp, Peoria, IL, 4/26/06, **invited talk**.
110. "Electrochemical Measurements on Stainless Steel using a Kelvin Probe Potentiostat," G. S. Frankel, North Dakota State Univ., Dept. of Coatings and Polymeric Materials Seminar, 4/24/06, **invited talk**.
109. "Measurement of Oxygen Reduction and Breakdown Potentials on Stainless Steel using a Kelvin Probe," G.S. Frankel, B. Maier, M. Stratmann, A. Michalik, G. Paliwoda, and M. Wicinski, Research in Progress symposium NACE2006, San Diego, 3/15/06, **invited talk**.
108. "Localized Corrosion Growth Rates in AA7xxx Alloys," Tsai-Shang Huang, Xinyan Zhao, and G.S. Frankel, Army Corrosion Summit, Clearwater Beach, 2/16/06, **Invited Talk**.
107. "Activities in the Fontana Corrosion Center," G.S. Frankel, Colloquium, Ohio University, Athens, OH, 12/6/05. **Invited Talk**.

106. "Localized Corrosion Growth Rates in AA7xxx," Tsai-Shang Huang, Xinyan Zhao, and G.S. Frankel, Tri-Service Corrosion Conference, Orlando, 11/17/05.
105. "Effect of Stress on Localized Corrosion in Al Alloys," Xiaodong Liu, Zhijun Zhao, G. S. Frankel, B. Zoofan and S. I. Rokhlin, Tri-Service Corrosion Conference, Orlando, 11/14/05.
104. "Corrosion Protection of AA2024-T3 by Metavanadates and Vanadium-Based Conversion Coatings," M. Iannuzzi, G.S. Frankel, and R.G. Buchheit, ECS Meeting, Los Angeles, 10/18/05.
103. "Corrosion Reliability Prediction: Long Term Nuclear Waste Storage in Yucca Mountain," G. S. Frankel, 16<sup>th</sup> International Corrosion Congress, Beijing, 9/19/05. **Plenary Address.**
102. "Corrosion Curriculum at the Fontana Corrosion Center," 16<sup>th</sup> International Corrosion Congress, Beijing, 9/19/05. **Invited Talk.**
101. "Effect of Tensile and Compressive Stress on IGC and IGSCC in AA2024-T3", Xiaodong Liu, G. S. Frankel, B. Zoofan and S. I. Rokhlin, International Symposium on Progress in Corrosion Research in Commemoration of Centenary of Birth of Professor Go Okamoto, Sapporo, Japan, 9/15/05, **Invited talk.**
100. "Growth Kinetics of Intergranular and Exfoliation Corrosion in AA7xxx," Tsai-Shang Huang, Xinyan Zhao, and G. S. Frankel, Passivity-9, Paris, 6/30/05. **Keynote address.**
99. "In Situ AFM Scratching of High Strength Al Alloys," M. Iannuzzi, P. Schmutz, V. Gillaumin, P. Leblanc, and G.S. Frankel, AGEF Seminar on Tribocorrosion, Duesseldorf, 4/19/05. **Invited talk.**
98. "Hydrogen Embrittlement Resistance of Inconel Alloy MA754," N. Gingo, Z. Sun, G.S. Frankel, and D. Hardwick, Research in Progress Symposium, NACE Corrosion05, Houston, 4/4/05.
97. "Toward US-China Collaboration in Education and Academic Research," G.S. Frankel, NACE International Corrosion05, Houston, 4/4/05. **Invited talk.**
96. "Long Term Nuclear Waste Storage – The Most Important Materials Problem of Our Time," G.S. Frankel, Dept. of Materials Science and Eng. Colloquium, Ruhr-University Bochum, 4/1/05, **Invited talk.**
95. "Outlook for Corrosion Science," G. S. Frankel, Workshop on New Trends and Methods in Corrosion Research and Electrochemistry @ EMPA, Dubendorf, Switzerland, 2/15/05. **Invited talk.**

94. "Studies of Organic Coatings on Metals using Electrochemical Quartz Crystal Microbalance and Potential Pulse Testing," J. Kang and G. S. Frankel, Workshop on Applied Surface and Interface Analysis for Thin Film Coated Metals, Duesseldorf, 12/2/04. **Invited talk.**
93. "Imaging and Characterization of Multiple Stress Corrosion Cracks in AA2024-T3 by X-ray Radiography," Xiaodong Liu, G. S. Frankel, B. Zoofan and S. I. Rokhlin, ECS Meeting, Honolulu, HI, 10/4/04.
92. "Activities in the Fontana Corrosion Center," G. S. Frankel, Institute for Metal Research, Shenyang, China, 8/23/04.
91. "Novel Approach for Welding Stainless Steel Using Cr-Free Welding Consumables," Y. H. Kim, G. S. Frankel, G. Guaytima and J. C. Lippold, NACE Corrosion2004, New Orleans, 3/31/04.
90. "Novel Approach for Welding Stainless Steel Using Cr-Free Welding Consumables," Y. H. Kim, G. S. Frankel, G. Guaytima and J. C. Lippold, Army Corrosion Summit, Cocoa Beach, FL, 2/12/04.
89. "Growth Kinetics of Intergranular and Exfoliation Corrosion in AA7178," Tsai-Shang Huang, Xinyan Zhao, G. S. Frankel, B. Zoofan and S. I. Rokhlin, Triservice Corrosion Conference, Las Vegas, 11/20/03.
88. "Effect of Stress on Localized Corrosion in Al Alloys," Xiaodong Liu, Zhijun Zhao, G. S. Frankel, B. Zoofan and S. I. Rokhlin, Triservice Corrosion Conference, Las Vegas, 11/18/03.
87. "Characterization of the Region around MnS Inclusions in Stainless Steel," Qingjiang Meng, G. S. Frankel, H. Colijn, S. Goss, ECS Meeting, Orlando, 10/15/03.
86. "Inhibition of Al and Al Alloy Corrosion by Chromates," G. S. Frankel and R. L. McCreery, Michal Smialowski International Symposium on Corrosion and Hydrogen Degradation, Zakopane, Poland, 9/10/03, **Invited Talk.**
85. "Corrosion Science in the 21<sup>st</sup> Century," G. S. Frankel, International Symposium, Corrosion Science in the 21<sup>st</sup> Century, UMIST, Manchester, England, 7/7/03. **Introductory Plenary Address.**
84. "A New Method for Quantification of Exfoliation Rates and Assessment of Exfoliation Susceptibility," X. Zhao and G. S. Frankel, International Symposium, Corrosion Science in the 21<sup>st</sup> Century, UMIST, Manchester, England, 7/10/03.
83. "Application of Scanning Kelvin Probe Force Microscopy for Studies of Corrosion," G. S. Frankel, Seminar, Max Planck Institut fuer Eisenforschung, Duesseldorf, 5/5/03. **Invited Talk.**



82. "Effect of Cu Content on Corrosion Behavior and Chromate Protection of 7xxx Series Al Alloys," Q. Meng and G. S. Frankel, ECS Meeting, Paris, 4/30/03.
81. "Scanning Kelvin Probe Force Microscopy Studies of Corrosion," G. S. Frankel, MSE Colloquium, Johns Hopkins University, 4/9/03. **Invited Talk.**
80. "Electrochemical Quartz Crystal Microbalance Study on Au and Phases in AA2024-T3," G. S. Frankel, J. Kang, and Y. Back, NACE Corrosion2003, San Diego, 3/18/03.
79. "A New Test for Exfoliation Susceptibility and Kinetics: Exfoliation of Slices in Humidity," X. Zhao, T. Huang and G. S. Frankel, Research in Progress, NACE Corrosion2003, San Diego, 1/17/03.
78. "Potentiostatic Pulse Testing for Assessment of Early Coating Failure," J. Kang and G. S. Frankel, Army Corrosion Summit, Clearwater, FL, 2/13/03.
77. "Characterization of Corrosion and Corrosion Susceptibility of Metallic Surfaces by Scanning Kelvin Probe Force Microscopy," P. Leblanc and G. S. Frankel, Meeting of the Japanese Institute of Iron and Steel, Osaka, 11/3/02. **Invited talk.**
76. "Intergranular Corrosion Morphology and Growth Kinetics in High Strength Al Alloys," T.-S. Huang, X. Liu, X. Zhao, and G. S. Frankel, ECS Meeting, Salt Lake City, 10/21/02.
75. "Scanning Kelvin Probe Force Microscopy Studies of Corrosion," G. S. Frankel, MSE Colloquium, Lehigh University, 10/17/02. **Invited Talk.**
74. "Peer Review Panel Assessment of the Planned Waste Package Materials for Disposal of High Level Nuclear Waste at Yucca Mountain," G. S. Frankel, J. H. Payer, J. A. Beavers, T. M. Devine, Jr, R. H. Jones, R. G. Kelly, R. M. Latanision, TMS Annual Meeting, Columbus, OH, 10/7/02.
73. "Wagner-Traud To Stern-Geary; Development of Corrosion Kinetics," G. S. Frankel, ECS Meeting, Philadelphia, 5/13/02.
72. "Sulfide Stress Cracking Resistance of Welded High-Strength Low-Alloy Pipeline Steels," G. Omweg, G. S. Frankel, W. Bruce, J. Ramirez, G. Koch, NACE Corrosion 2002, Denver, 4/10/02.
71. "Intergranular Corrosion Growth Kinetics in High Strength Al Alloys," G. S. Frankel, Army Corrosion Summit, St. Petersburg, 3/6/02.
70. "Localized Corrosion Growth Kinetics in Al Alloys," G. S. Frankel, 2002 Triservice Corrosion Conference, San Antonio, 1/18/02.

69. "Inhibition of Al Alloy Corrosion by Chromate," G. S. Frankel, 2002 Triservice Corrosion Conference, San Antonio, 1/18/02.
68. "Localized Corrosion of Al Alloys," G. S. Frankel, Rockwell Science Center Seminar, 12/7/01.
67. "Studies of Corrosion using Scanning Kelvin Probe Force Microscopy," G. S. Frankel, 12<sup>th</sup> Asia-Pacific Corrosion Control Conference 2001, Seoul, Korea, 10/10/01, **Plenary Lecture**.
66. "Scanning Kelvin Probe Force Microscopy and AFM Scratching Studies of Corrosion," G. S. Frankel, Departmental Colloquium Series, MSE, OSU, 5/18/01.
65. "Intergranular Corrosion and Stress Corrosion Cracking of AA2024-T3," X. Liu, W. Zhang, and G. S. Frankel, NACE2001 Research Technical Symposium, Houston, 3/13/01, **Invited Talk**.
64. "Effect of Stress on Penetration of Intergranular Corrosion in Aluminum Alloys; Transition of IGC to IGSCC," X. Liu, W. Zhang, and G. S. Frankel, TMS Conference, New Orleans, 2/15/01.
63. "Open Circuit Pit Growth in Al," D. Lu and G. Frankel, ECS Meeting, Phoenix, 10/26/00.
62. "Scanning Kelvin Probe Force Microscopy Studies of Corrosion," P. Schmutz, V. Guillaumin, D. Devecchio, G. S. Frankel, ACS Meeting, Washington, DC, 8/23/00, **Invited Talk**.
61. "Activities in the Fontana Corrosion Center," G. S. Frankel, Luoyang Ship Materials Research Institute, Qingdao, 8/4/00, Institute for Corrosion and Protection of Materials, Shenyang, 8/8/00, Corrosion and Protection Centre, University of Science and Technology Beijing, 8/10/00. **Invited Talk**.
60. "Assessment of Localized Corrosion Kinetics in Aluminum Alloys," G. S. Frankel, Univ. of Cincinnati, Dept of Materials Science Seminar, 6/2/00.
59. "Scanning Kelvin Probe Force Microscopy Studies of Passive Surfaces," P. Schmutz, V. Guillaumin, and G. S. Frankel, MRS Meeting, San Francisco, 4/00. **Invited Talk**.
58. "Role of Microstructure and Grain Boundary Constituents on Pitting and Intergranular Corrosion of Aluminum Alloys," T. Ramgopal, W. Zhang, and G. S. Frankel, NACE Corrosion2000, Orlando, 3/00.
57. "A New Approach for the Study of Chemical Mechanical Polishing," D. Devecchio, P. Schmutz, and G. S. Frankel, 1999 ECS Fall Meeting, Honolulu, 10/21/99.
56. "Intergranular Corrosion of High Strength Al Alloys", W. Zhang, T. Ramgopal, and G. S. Frankel, Triservice Corrosion Conference, Myrtle Beach, 11/17/99.

55. "Localized Corrosion of Metals: A Review of the Critical Factors in Initiation and Growth," G. S. Frankel, Passivity-8, Jasper, Canada, 5/99, **Keynote address**.
54. "Study of Localized Corrosion of Al and Al Alloys by AFM Scratching," P. Schmutz and G. S. Frankel, Research in Progress Symposium, NACE Corrosion99, San Antonio, 4/26/99, **Invited Talk**.
53. "The Susceptibility of Conventional ASTM A516-70 to HIC and SOHIC in H<sub>2</sub>S-Containing DGA Environments," M. Al-Anezi, G. S. Frankel, and A. Agrawal, NACE Corrosion99, San Antonio, 4/26/99.
52. "Corrosion of Aging Aircraft and Corrosion-Sensing Paint", G. S. Frankel, McMaster Univ., Hamilton, Ontario, 3/12/99.
51. "Mechanism of Al Alloy Corrosion and the Role of Chromate Inhibitors", G. S. Frankel, Cleveland section meeting of The Electrochemical Society, 12/9/98.
50. "Corrosion Sensing Coating Systems," J. Zhang and G. S. Frankel, ECS Fall Meeting, Boston, 11/98.
49. "Corrosion of Electronic and Magnetic Materials and Devices," G. S. Frankel, ASM Annual Meeting, Rosemont, IL, 10/13/98.
48. "Mechanism of Al Alloy Corrosion and the Role of Chromate Inhibitors", G. S. Frankel, AFOSR/DARPA review meeting, 9/28/98.
47. "Effects Of Inhibitor Ions On The Growth Of Pits In Thin Film Aluminum", G. S. Frankel, AFOSR/DARPA review meeting, 9/28/98.
46. "Effects of Chromate Ions on Localized Corrosion of Al and Al Alloys," G. S. Frankel, P. Schmutz, E. Akiyama, W. Zhang, D. Lu, and A. Sehgal, AFRL Workshop on Advanced Metal Finishing Techniques for Aerospace Applications, Keystone, CO, 8/27/98, **Invited Talk**.
45. "Scanning Kelvin Probe Force Microscopy", G. S. Frankel, Aqueous Corrosion Gordon Conference, New London, NH, 7/7/98, **Invited Talk**.
44. "Exfoliation and Intergranular Corrosion of Al Alloys", T. Ramgopal, and G. S. Frankel, Aeromat 98, Tysons Corner, VA, 6/18/98.
43. "Effects of Chromate Ions on Pitting of AA1100-0 and AA2024-T3," P. Schmutz, A. Sehgal, and G. S. Frankel, ECS Spring Meeting, San Diego, 5/98.
42. "Novel Applications of Scanning Probe Microscopy to the Study of Localized Corrosion," G. Frankel, Penn State University Department of Engineering Science and Mechanics Colloquium, 4/8/98, **Invited Talk**.

41. "Localized Corrosion and Stress Corrosion Cracking Susceptibility of Friction Stir Welded AA 5454," Z. Xia and G. S. Frankel, Research in Progress Symposium, NACE Corrosion 98, San Diego, 3/98, **Invited Talk**.
40. "Characterization of AA 2424-T3 by Scanning Kelvin Probe Force Microscopy," P. Schmutz and G. S. Frankel, Research in Progress Symposium, NACE Corrosion 98, San Diego, 3/98.
39. "Mechanism of Al Alloy Corrosion and the Role of Chromate Inhibitors", G. S. Frankel, Special Seminar, MIT, 12/1/97.
38. "Paint as a Corrosion Sensor, A comparison of the sensitivity of different coating systems", J. Zhang and G. S. Frankel, Tri-Service Corrosion Conference, Wrightsville Beach, NC, 11/18/97.
37. "Paint as a Corrosion Sensor; Acrylic Coating Systems", J. Zhang and G. S. Frankel, MRS Meeting, Boston, 12/1/97.
36. "Mechanism of Al Alloy Corrosion and the Role of Chromate Inhibitors", G. S. Frankel, Central Michigan ECS Local Section Meeting, Midland Michigan, 10/29/97.
35. "Corrosion: A Tutorial with a Focus on Coatings and Inhibitors", Special Seminar, G. S. Frankel, Dow Corp, Midland Mich., 10/29/97.
34. "Paint as a Corrosion Sensor", J. Zhang and G. S. Frankel, 3rd Workshop on Quantitative Methods for Predicting Coating Performance, Naval Surface Warfare Center, Carderock, MD, 10/20/97, **Invited Talk**.
33. "A Study of Pit Growth in Al Thin Films", D. Lu, A. Schgal, and G. S. Frankel, Fall ECS Meeting, Paris, 9/97, **Invited Talk**.
32. "Studies of Pitting Corrosion of Al and Al Alloys", P. Schmutz, J. Zhang, and G. S. Frankel, Swiss Federal Technical Institute, Zurich, Switzerland, 8/26/97.
31. "Studies of Pitting Corrosion of Al and Al Alloys", P. Schmutz, J. Zhang, and G. S. Frankel, Ecole Polytechnique, Lausanne, Switzerland, 8/22/97.
30. "Pitting Corrosion: A Review of the Critical Factors", G. S. Frankel, Spring ECS Meeting, Montreal, 5/97, **Keynote Talk**.
29. "Paint as a Corrosion Sensor", G. S. Frankel and J. Zhang, Corrosion 97, New Orleans 3/11/97, **Invited Talk**.
28. "Corrosion of Electronic And Magnetic Devices And Materials," G.S. Frankel, MRS Fall Meeting, Boston, 12/2/96. **Invited Talk**.

27. "Effects Of Inhibitor Ions On The Growth Of Pits In Thin Film Aluminum," D. Lu, A. Sehgal, G.S. Frankel, Fall ECS Meeting, San Antonio, 10/10/95, **Invited Talk**.
26. "Corrosion of Electronic and Magnetic Materials; Future Problems and Challenges," G.S. Frankel, Gordon Conference on Aqueous Corrosion, New London, NH, 7/9/96, **Invited Talk**.
25. "Corrosion and Deuterium Uptake in Zr Alloy CANDU Pressure Tubes - A Critical Assessment," G.S. Frankel, AECB and Ontario-Hydro, Toronto, 6/27/96.
24. "Corrosion, A Tutorial with a Focus on Magnetic Materials," G. S. Frankel, Read-Rite Corp., Fremont, CA, 6/19/96.
23. "Corrosion, A Tutorial with a Focus on Magnetic Storage," G. S. Frankel, Hoya USA, San Jose, CA, 4/9/95.
22. "Corrosion Studies Of Magnetic Storage Devices," G.S. Frankel, MRS Spring Meeting, San Francisco, 4/8/96. **Invited Talk**.
21. "Corrosion, A Tutorial with a Focus on Electronic and Magnetic Materials," G. S. Frankel, 3M Technical Forum, Austin, 3/28/96.
20. "Corrosion - It's the Pits," G.S. Frankel, CMR Lunchtime Seminar Series, The Ohio State University, 1/18/96
19. "Corrosion of Thin Metallic Films in Computer Applications," G. S. Frankel, ECS Columbus Section Meeting, Battelle, 10/27/95.
18. "Corrosion, A Tutorial with a Focus on Magnetic Storage," G. S. Frankel, HMT Technology Corp., Fremont, 10/20/95.
17. "Repassivation of Pits in Al Thin Films," G. S. Frankel, J. R. Scully, and C. V. Jahnes, Fall ECS Meeting, Chicago, 10/9/95. **Invited Talk**.
16. "Corrosion of Thin Metallic Films," G. S. Frankel, Materials Science and Engineering Departmental Colloquium, University of Virginia, Charlottesville, VA, 4/3/95. **Invited Talk**.
15. "Corrosion and Adhesion of Multilayer Pad Structures for Packaging Applications," G. S. Frankel, S. Puroshothaman, T. A. Petersen, S. Farooq, S. N. Reddy, V. Brusich, Electrochemical Society Meeting, Miami Beach, 10/12/94. **Invited Talk**.
14. "Repassivation Transients Measured with the Breaking Electrode Technique on Aluminum Thin-Film Samples," G.S. Frankel, C. V. Jahnes, V. Brusich, A. J. Davenport, Electrochemical Society Meeting, Miami Beach, 10/12/94.

13. "Studies of Pitting Corrosion in Thin Metallic Films," G. S. Frankel, Gordon Research Conference, 7/12/94. **Invited Talk.**
12. "Periodic Passivation of CuP Anodes during Electrodeposition of Cu from Acid-Sulfate Electrolyte," G. S. Frankel, J. O. Dukovic, J. Horkans, Electrochemical Society Meeting, New Orleans, 10/13/93.
11. "On the Pitting Resistance of Sputtered Al Alloys," G. S. Frankel, R. C. Newman, C. V. Jahnes, M. A. Russak, Electrochemical Society Meeting, Honolulu, 5/19/93.
10. "Studies of Pitting Corrosion in Thin Metallic Films," G. S. Frankel, National Institute of Standard & Technology, Gaithersburg, 1/13/93.
9. "Behavior of CuP Anodes under Electrodeposition Conditions," G. S. Frankel, A. G. Schrott, H. S. Isaacs, J. Horkans, P. C. Andricacos, Electrochemical Society Meeting, Toronto, 10/13/92.
8. "Pit Growth in NiFe Thin Films," G. S. Frankel, J. O. Dukovic, B. M. Rush, V. A. Brusic, and C. V. Jahnes, Electrochemical Society Meeting, Phoenix, 10/13/91.
7. "Experimental Techniques in Corrosion Science and Technology," G. S. Frankel, ASM International Electronic Materials and Processing Congress (4th), Montreal, Canada, 8/19/91.
6. "Passivation and Pitting of Sputtered Al Binary Alloys," G. S. Frankel, C. V. Jahnes, M. A. Russak, M. Mirzamaani, B. M. Rush, A. J. Davenport, H. S. Isaacs, Meeting of ONR-sponsored Contractors Studying Al Corrosion, Baltimore, 6/20/90.
5. "Corrosion Studies of Thin Films," G. S. Frankel, B. M. Rush, V. A. Brusic, S. M. Mirzamaani, and A. J. Davenport, Electrochemical Society Meeting, Seattle, WA, 10/14/90.
4. "Pitting of Aluminum and Aluminum Alloy Thin Films," G. S. Frankel, M. A. Russak, M. Mirzamaani, V. Brusic, C. Jahnes, Corrosion 89, New Orleans, 4/17/89.
3. "Pit Stability in Stainless Steels: The Transition from Metastability," G. S. Frankel, International Conference on Localized Corrosion, Orlando, 6/4/87.
2. "Metastable Pitting of Stainless Steel," G. S. Frankel, L. Stockert, F. Hunkeler, H. Bohni, Corrosion 86, San Francisco, 3/11/86.
1. "Dislocation Transport of Hydrogen in Poly- and Single Crystal Ni," G. S. Frankel, and R. M. Latanision, MRS Fall Meeting, Boston, 12/1/84.

### **Sponsored Research**

1. AFOSR  
*The Influence of Inhibitor Ions and Conversion Coatings on Localized Corrosion of Al and Al Alloys*  
RF 732039  
G. S. Frankel  
2/15/1996 - 02/14/1999  
\$573,011, includes \$140,000 from WPAFB to support work on *Paint as a Corrosion Sensor*
2. IBM  
*Electrochemical Impedance Spectroscopy Study of Polymer/Metal Composite Paste Materials*  
RF 732664  
G. S. Frankel  
10/1/95 - 9/28/97  
\$62,955, plus \$18,333 OSU seed grant
3. Edison Welding Institute  
*Corrosion and Stress Corrosion Cracking Resistance of Al Alloy Friction Stir Welds*  
RF 732563  
G.S. Frankel  
7/1/96- 6/30/97  
\$25,000, plus \$15,000 matching funds from WPAFB
4. Department of Defense, MURI  
*Mechanism of Al alloy corrosion and the role of chromate inhibitors*  
RF 732915  
G. S. Frankel, lead PI, with 6 co PIs from various organizations: R. L. McCreery, C. Clayton, R. Granata, H. S. Isaacs, M. Kendig, M. Stratmann  
9/30/1996 - 9/29/2001  
\$5,000,000, \$2.6M subcontracted to other institutions
5. WPAFB, subcontract through TMC  
*Exfoliation Corrosion of Al Alloys*  
RF 733543  
G. S. Frankel  
1/20/97 - 11/19/99.  
\$215,000, plus \$3,000 in matching funds from OSU
6. AFOSR  
*Measurement of localized corrosion propagation rates in Al and Al alloys*  
G. S. Frankel  
RF 737103  
2/15/1999 - 11/14/2001  
\$463,744
7. SERDP

- Critical Factors for the Transition from Chromate to Chromate-Free Corrosion Protection*  
 RF 737176  
 R. G. Buchheit, lead PI, G. S. Frankel, R. L. McCreery, M. Donley, J. Beatty  
 2/99 - 2/03  
 \$2,062,885 total, ~\$200,000 for GSF
8. OSU Office of Research, Biomaterials Seed Grant  
*Electrochemical Impedance Assessment of Titanium Implant Alloys Based on Cell Coverage*  
 G.S. Frankel and P. Monaghan  
 5/99-5/01  
 \$30,000
9. Edison Welding Institute  
*SSC of welded high strength pipeline steels in sour environments*  
 RF 737923  
 7/01/1999 - 6/30/2001  
 \$110,000
10. Department of Defense, MURI, Subcontract through UDRI  
*NDE of Corrosion*  
 RF 739176  
 G. S. Frankel and S. Rokhlin  
 1/1/00 - 8/31/01  
 \$257,100 (\$153,304 for GSF)
11. US Army, subcontracted through CTC  
*Corrosion Control and Assessment Methods for US Army Assets*  
 R. G. Buchheit, Lead PI, G. S. Frankel, S. Lemeshow  
 RF 740877, 740878, 740879  
 4/1/2001 - 12/31/01  
 \$304,338, split evenly  
 RF 742940  
 1/1/2002-12/31/2002  
 \$178,000, \$140,500 for GSF  
 RF 746127, 746128  
 4/1/3004-8/31/2004  
 \$175,000, \$85,000 for GSF  
 RF 60002244, 60002245  
 9/1/2004-6/30/2005  
 \$100,000, \$50,000 for GSF  
 RF 60004431, 60005699  
 5/23/05 - 3/30/06  
 \$40,000, \$20,000 for GSF
12. Air Force Research Labs, subcontracted through NCI  
*Intergranular and Exfoliation Corrosion Rate Studies*



- RF 741467  
G. S. Frankel and S. Rokhlin  
7/11/2001-7/10/2002  
\$100,000, \$75,000 for GSF
13. DOE SBIR, subcontract through Omega International Technologies  
*High resolution imaging system for corrosion measurement*  
RF 741895  
G. S. Frankel  
9/30/2001-03/31/2002  
\$15,000
14. AFOSR  
*Effects of Stress on Localized Corrosion in Al and Al alloys*  
RF 7422142 and 742820  
G. S. Frankel and S. Rokhlin  
3/1/2002 - 12/31/2004  
\$624,563, \$469,616 for GSF
15. Air Force, subcontracted through SKT  
*Intergranular and Exfoliation Corrosion Rate Studies*  
G. S. Frankel and S. Rokhlin  
RF 742940  
1/1/2002-12/31/2002  
\$178,000, \$140,500 for GSF  
RF 744162  
1/1/2003-3/31/2004  
\$178,778, \$135,000 for GSF  
RF 746516  
4/1/2004-12/31/2005  
\$175,000, \$149,000 for GSF
16. AFOSR  
*Mechanism and Inhibition of Oxygen Reduction*  
RF 742142  
R. L. McCreery and G. S. Frankel  
7/1/2002-12/31/2005  
\$446,933, split evenly
17. SERDP  
*Novel Approach for Welding Stainless Steel Using Cr-free Consumables*  
G. S. Frankel and J. Lippold  
RF 743970, 746136, 746136, 746137  
1/1/03-12/31/04  
\$200,000, \$130,000 for GSF

*Development of Cr-free Welding Consumables for Stainless Steels*

G. S. Frankel and J. Lippold

RF 60004779, 60003312, 60000801

1/1/2005 – 9/30/2008

\$1,238,055, ~\$450,000 for GSF

18. NATO Travel Grant

*Study of corrosion processes on aluminium alloys by means of electrochemical noise*

RF 744221

G. S. Frankel and R. G. Buchheit

1/1/03-12/31/04

\$10,244, split evenly

19. John Glenn Research Center - Lewis Field

*Intelligent Propulsion System Foundation Technology, Hot Corrosion*

R. A. Rapp and G. S. Frankel

RF 745584

9/1/03-8/31/04

\$98,750, split evenly

20. Air Force Materiel Command

*Development of a methodology for hydrogen embrittlement resistance*

G. S. Frankel, H. L. Fraser

RF 746119

1/1/04-8/31/05

\$130,000, all for GSF

21. DOE, subcontracted through Case Western Reserve Univ.

*Corrosion and Materials Performance Studies*

G. S. Frankel and R. G. Buchheit

RF 747099

7/1/2004-5/31/2004

\$1,302,500, split evenly

22. AFOSR, subcontracted through North Dakota State Univ.

*Effects of Stress on Localized Corrosion in Al and Al Alloys*

G. S. Frankel and S. I. Rokhlin

RF 60001605, 60003249

10/1/2004 – 10/1/2006

\$200,000, \$150,000 for GSF

23. AFOSR, subcontracted through North Dakota State Univ.

*Localized Corrosion of High Strength Al Alloys*

G. S. Frankel

RF 60004033

10/1/2004 – 10/1/2006

\$214,954

24. Henkel Corp.  
Bonderite NT-1 Study  
RF 60006118  
1/01/2006 - 2/28/2011  
\$375k
25. US Council for Automotive Research, through Robert C. McCune and Assoc.  
*Corrosion resistance assessment of pre-treated magnesium alloys by electrochemical methods*  
G. S. Frankel  
RF 60012657, 60018412  
6/1/2007 – 5/31/2008, 10/1/08-09/30/09  
\$100,000
26. Office of Sec. Defense through Mandaree Enterprise Corp.  
*Causes of Discrepancies between Field and Laboratory Corrosion Tests*  
G.S. Frankel and H.C. Allen  
RF 60013168  
7/1/2007 – 6/30/2008  
\$40,000, split evenly
27. SERDP  
*Scientific understanding of non-chromated corrosion inhibitors function*  
G. Frankel, R. Buchheit, G. Swain (Michigan State), and M. Jawarowski (United Tech.)  
RF 60012546, 60015889, 60015890  
3/24/2008 - 3/23/2012  
\$2.648M total, \$1.649M for OSU, ~\$825k for GSF
28. Office of Sec. Defense through Mandaree Enterprise Corp.  
*Collaborative university research on corrosion*  
G. Frankel, R. Buchheit, H. Allen (Chemistry)  
RF 60016989, 60017793, 60017794  
1/01/2008 - 5/15/2012  
\$1,175,000 total, \$575k for GSF
29. Office of Sec. Defense through US Army Research Development and Engineering Command  
*Degradation of Polymer Coated Metals*  
G. Frankel, R. Buchheit, H. Allen (Chemistry)  
RF 60020965, 60020970, 60020971  
7/16/2009 - 7/15/2013  
\$1,000,000 total, \$456k for GSF
30. Pohang Steel Corp.  
*The effects of inclusions on the corrosion of 21Cr ferritic stainless steels*

RF 60024197  
11/1/2009 – 10/31/2010  
\$50,000

31. Office of Naval Research

*An assessment of science and technology for supporting advances in marine service coatings for the U.S. Navy*

RF 60025445  
5/1/2010 – 4/30/2011  
\$100,000 total, \$35k for GSF

32. Air Force Academy

*Corrosion models and mechanistics to support assessment and prognostic tools for managing corrosion of DOD facilities and equipment* RF 60025445

3/24/2010 – 3/23/2014  
\$1,000,000 total, \$363,977k for GSF

### **Development Gifts**

1. Det Norske Veritas (DNV)

*DNV Chair in Corrosion*  
G. S. Frankel  
7/1/2007 – 6/30/2010  
\$480,000

### **Equipment Grants**

1. Matching funds on AFOSR equipment money in contract entitled *Al and Al Alloy Corrosion*.

G. S. Frankel  
1996  
\$85,000 from Ohio Board of Regents Action Fund + \$85,000 from OSU

2. AFOSR DURIP

*Localized Corrosion Analysis Laboratory*

R. G. Buchheit and G. S. Frankel  
1998  
\$150,975 + \$75,487 from Ohio Board of Regents Action Fund + \$75,487 from OSU

3. AFOSR

*Corrosion and Coatings Instrumentation*

R. G. Buchheit G. S. Frankel, and R. L. McCreery  
1999  
\$220,000 + \$110,000 from Ohio Board of Regents Action Fund + \$110,000 from OSU

4. National Science Foundation

*Acquisition of multiuser x-ray photoelectron spectrometer for materials research and education*

R. L. McCreery, P. Dutta, G. Frankel, U. Ozkan, A. Epstein  
2002

\$300,000 + \$150,000 from Ohio Board of Regents Action Fund + \$150,000 from OSU

5. DOE

*Equipment for Corrosion and Materials Performance Studies*

G. S. Frankel and R. G. Buchheit  
2004

\$120,000 + \$60,000 from Ohio Board of Regents Action Fund + \$60,000 from OSU

**Teaching**

Teach three different classes in corrosion at OSU: an undergraduate level class including a laboratory, a graduate level class, and an advanced graduate level class for PhD students. Co-organizer and lecturer for two annual short courses on corrosion for professionals: at Ohio State and Penn State Universities. Also teach other undergraduate courses at OSU.

**OSU Service**

University Doctoral Program Assessment Committee	2008
Welding Engineering Transition Planning Committee	2007
University Senate Faculty Hearing Committee	2006-2010
MSE Interim Executive Committee	2003-2004
MSE Graduate Studies Committee	1995-2002
MSE Chair Advisory Committee	1999-present
MSE Promotion and Tenure Committee, chairman	2002-2004
University Research Committee, member	2000-2003
University Research Committee, chairman	2001-2003
University Senate Ad Hoc Budget Restructuring Review Comm.	2003-2004
College of Engineering Promotion and Tenure Committee	2002-2004
VP Research Advisory Committee	2001-2003
Faculty Search Committees:	
Corrosion professor	1997
Honda Chair	1999
Computational materials professors	2000-2001
MSE Department Head	2003

**Professional Service**

The Electrochemical Society

Board of Directors, The Electrochemical Society, 2002-2004  
Corrosion Division Chairman, The Electrochemical Society, 2002-2004  
Corrosion Division Vice Chairman, The Electrochemical Society, 2000-2002  
Corrosion Division Secretary, The Electrochemical Society, 1998-2000  
Corrosion Division Executive Committee, The Electrochemical Society, 1994-2009  
Finance Committee, The Electrochemical Society, 1998-2000

Membership Committee, The Electrochemical Society, 2000-2004  
Chairman, Membership Committee, The Electrochemical Society, 2003-2004  
Technical Affairs Committee, The Electrochemical Society, 2005-2009  
Awards Committee, The Electrochemical Society, 2009-present

#### NACE

Board of Editors for *Corrosion* Journal, 1997-present  
NACE Research Committee Chairman, 2004- 2006  
NACE Research Committee Vice Chairman, 2002-2004  
NACE Research Committee member, 1996-present  
NACE Uhlig Award Committee member, 2002-present  
NACE Uhlig Award Committee chairman, 2005-present

#### Boards, Committees, and Panels

Editorial board, *Corrosion, Materials and Corrosion, Corrosion Reviews*.  
DOE Waste Package Materials Performance Peer Review Panel, 2001  
DOE Expert Panel Workshop on Double Shell Tank Chemistry Optimization, 2004.  
DOE Double Shell Tank Chemistry Optimization Expert Panel Oversight Committee, 2005-present.  
Corrosion Education Workshop Organizing Committee, sponsored by The National Academies, National Materials Advisory Board, 2007.  
Committee on Assessing Corrosion Education, sponsored by The National Academies, National Materials Advisory Board, 2007-2008.  
Committee on Research Opportunities in Corrosion Science and Engineering, sponsored by The National Academies, National Materials Advisory Board, 2008-2010.  
DOE Expert Panel Workshop on Single Shell Tank Integrity, 2008-present.  
Scientific Advisory Board, Henkel North America, 2008-present.

#### **Symposia Organized, partial list**

"ISE Spring Meeting in honor of the 100<sup>th</sup> Birthday of Mars Fontana," 5/10, Columbus.  
"Corrosion Protective Surface Coatings," Fall ECS Meeting, 10/09, Vienna  
"Critical Factors in Localized Corrosion, VI, in honor of Prof. Shibata," Fall ECS Meeting 10/08, Honolulu  
"Critical Factors in Localized Corrosion, IV, in honor of Hans Bochni," Fall ECS Meeting, 10/02, Salt Lake City.  
"Corrosion Science, A Perspective and Current Status, a symposium in honor of Robert P. Frankenthal, Spring ECS Meeting, 4/02, Philadelphia.  
"Localized Corrosion," Research Topical Symposium, NACE, Corrosion01, Houston  
Gordon Conference on Aqueous Corrosion, July, 2000, New London, NH.  
"Critical Factors in Localized Corrosion, III," Fall ECS Meeting, 11/98, Boston.  
"Organic and Inorganic Corrosion Inhibitors," Spring ECS Meeting, 5/98, San Diego.  
"Research in Progress," NACE Corrosion98, 3/98, San Diego.  
"Critical Factors in Localized Corrosion, II," Fall ECS Meeting, 10/95, Chicago.  
"Critical Factors in Localized Corrosion," Fall ECS Meeting, 10/91, Phoenix.

### **Awards to Students**

Greg Omweg, 1<sup>st</sup> place, STG 34 Refining and Gas Processing Student Poster Award, NACE Corrosion2001, Houston.

Xiaodong Liu, 2nd place, Mars Fontana Student Poster Award in Corrosion Engineering, NACE Corrosion2002, Denver.

Qingjiang Meng, 3rd place, Marcel Pourbaix Student Poster Award in Corrosion Science, NACE Corrosion2002, Denver.

Xinyan Zhao, 2<sup>nd</sup> place, Harvey Herro Student Poster Award in Applied Corrosion Technology, NACE Corrosion2003, San Diego.

Jiho Kang, 3rd place, Mars Fontana Student Poster Award in Corrosion Engineering, NACE Corrosion2003, San Diego.

**Thodla Ramgopal, Morris Cohen Graduate Student Award of the ECS Corrosion Division, 2003.**

Greg Omweg, W. H. Hobart Award from the American Welding Society for best contribution to Welding Journal in the area of pipe welding, 2004.

**Qingjiang Meng, Morris Cohen Graduate Student Award of the ECS Corrosion Division, 2004.**

Yeong Ho Kim, 2<sup>nd</sup> Place, Mars Fontana Student Poster Award in Corrosion Engineering, NACE Corrosion2004, New Orleans.

Mariano Iannuzzi, 1<sup>st</sup> Place, Marcel Pourbaix Student Poster Award in Corrosion Science, NACE Corrosion2006, San Diego.

Mariano Iannuzzi, Graduate Student Book Award from the NACE Foundation, 2006.

Dong Liang, 1<sup>st</sup> Place, Mars Fontana Student Poster Award in Corrosion Engineering, NACE Corrosion2008, New Orleans.

Dong Liang, Graduate Student Book Award from the NACE Foundation, 2009.

**Mariano Iannuzzi, Morris Cohen Graduate Student Award of the ECS Corrosion Division, 2009.**

### **Consultancy (partial list)**

HMT Technology, Inc, helped develop corrosion measurement capability, 1996.

Atomic Energy Control Board of Canada, assessed research program on deuterium uptake by Zr alloys and developed model, 1996.

Carpenter Technology, expert witness regarding corrosion failure, 1996-98.

ASIMI, expert witness regarding reactor failure, 1997-99.

Ford Motor Corp, tube corrosion problem, 1997.

In-Sink-Erator (division of Emerson Electric Co.), consultation on new disposer design, 1998.

City of Columbus, expert witness regarding personal injury claim, 1999.

Dormont Manufacturing, advice on failure analyses, 1999-2006.

Gilbane Construction, advice on corroded Al window frames, 1999.

OLI Systems, Inc., member of Academic Review Board on DOE project 2000-2002.

Holophane, advice on lighting fixtures, 2001-2002.

Seagate Technology, advice on electrochemical testing, 2003.

CH2M Hill Hanford Group, advice on corrosion of waste storage tanks, 2004-2010

Lexmark Corp, advice on corrosion, 2007